Space Weather Technical Forecast

Issued on Tuesday, 10 January 2023 at 01:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares likely, chance of X-class flares throughout. Chance of Active fluence by Day 4 (12 Jan). A possible glancing blow from a CME on the 12th January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with an X1.9 flare observed at 09/1850 UTC, which originated from AR3184 near the southeast limb. This did cause an R2-R3 radio blackout on the Sun facing side of Earth. AR3184 is still emerging from the southeast, although is now visible enough to give it a Dkc/Beta-Delta configuration, with a delta spot seen in its trailing spots. There are five other numbered sunspot regions on the visible disc. AR3181 in the southwest quadrant gave an M2 flare, observed at 09/0901 UTC, which produced a CME. This has been analysed and may give a glancing blow at Earth on day 3 (12 Jan), although confidence is low. AR3184, AR3182 and AR3181 are the three largest and most complex regions on the visible disc, with all regions harbouring delta spots. The remaining three spots are all relatively small and have remained stable. There is a new and currently unnumbered region emerging on the northeast limb, which has recently produced an M5 flare, observed 10/0016 UTC. No other Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by DSCOVR at L1, have declined to slow ambient levels through the period. Wind speeds were initially slightly elevated, just above 400km/s, declining to near 330km/s. Density was average or below average. Total IMF, Bt, was weak at 6 nT or below. The north-south component, Bz, varied weakly between +/-5 nT. Phi angle was predominately negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2) throughout.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2 MeV) has been at background to moderate levels, with a peak of 301 pfu observed at 09/1815 UTC. The 24-hour integrated electron fluence stayed well below the Active threshold, reaching 3.91e6 integrated pfu at 10/0001 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low to Moderate, with a chance of X-class flares through the forecast period, these most likely from AR3182, AR3181 or AR3184 which is currently emerging around the southeast limb.

Solar Wind / Geomagnetic Activity: The M2 flare from AR3181 in the southwest did produce a CME, which has been analysed and may give a glancing blow at Earth on day 3 (12th Jan). This may enhance geomagnetic activity on the 12th Jan, although confidence is low. No other Earth-directed CMEs are in the forecast. Solar wind speeds are now at ambient levels. However, the next feature of interest is CH62/-, with the HSS likely to arrive on Day 1 (10 Jan). Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 1 to

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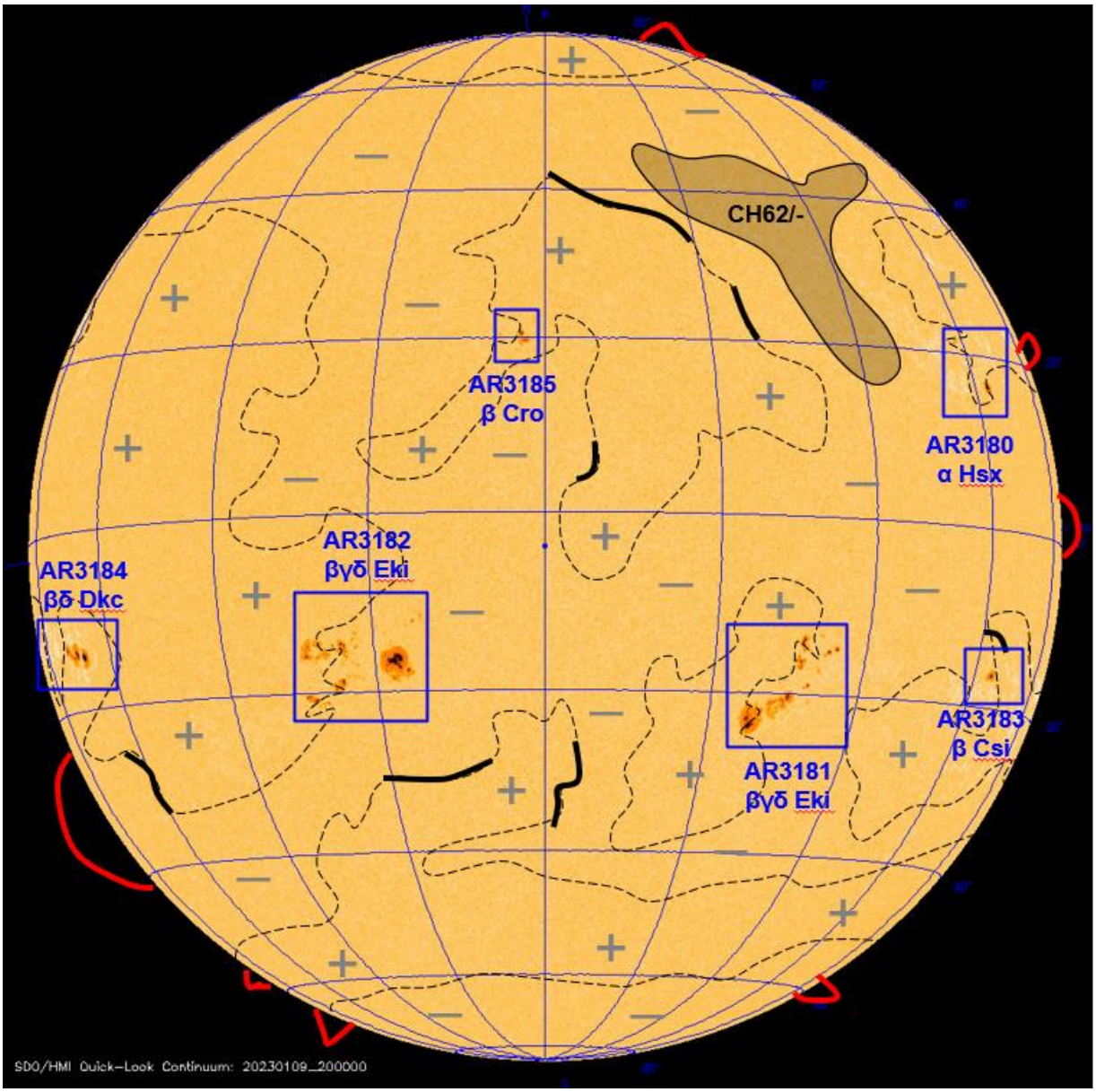
become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining through by day 2 (11th Jan) and possibly day 3 (12th Jan), although there is the slight chance of a glancing blow from aforementioned CME, which may increase geomagnetic activity, probably lasting into day 4 (13th Jan), before gradually declining.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at background levels throughout. However, there is a risk of an increase should any significant flares occur, giving a slight chance of exceeding the S1/Minor Storm threshold. Electron fluence is likely to remain below the Active (1e8 integrated pfu) threshold, but a rise is possible towards the end of the period, depending on any glancing CME on day 3 (12th Jan).

Figure 1. Solar Analysis Valid 09/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

AR3181 in the southwest produced an M2 flare, observed at 09/0901 UTC, which produced a CME. This has been analysed and may give a glancing blow at Earth on Day 3 (12 Jan), although this is low confidence. No other Earth-directed CMEs are currently expected in the forecast.

Solar wind speeds are now at ambient levels after a weak High Speed Stream (HSS). The next feature of interest is CH62/-, with the HSS likely to arrive on Day 1 (10 Jan). This feature was faintly visible on the previous rotation but didn't produce a HSS. It is much more clearly visible this time around, suggesting it is more intense and therefore more likely to give an increase in wind speeds on this rotation. The timing of arrival has been estimated from empirical techniques due to the lack of persistence data, but recent STEREO-A data suggests it is unlikely to arrive until at least later on Day 1 (10 Jan). MOSWOC Enlil is currently bringing the HSS in too early, with this suggesting it should have already arrived.

Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 1 (10 Jan) to become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining on Day 2 (11 Jan), before increasing again on Day 3 (12 Jan) due to a possible glancing blow from a CME - this is low confidence. Becoming mostly Quiet to Unsettled on Day 4 (13 Jan).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	5	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

A possible CME may glance Earth on Day 3 (12th Jan) – although this is low confidence.

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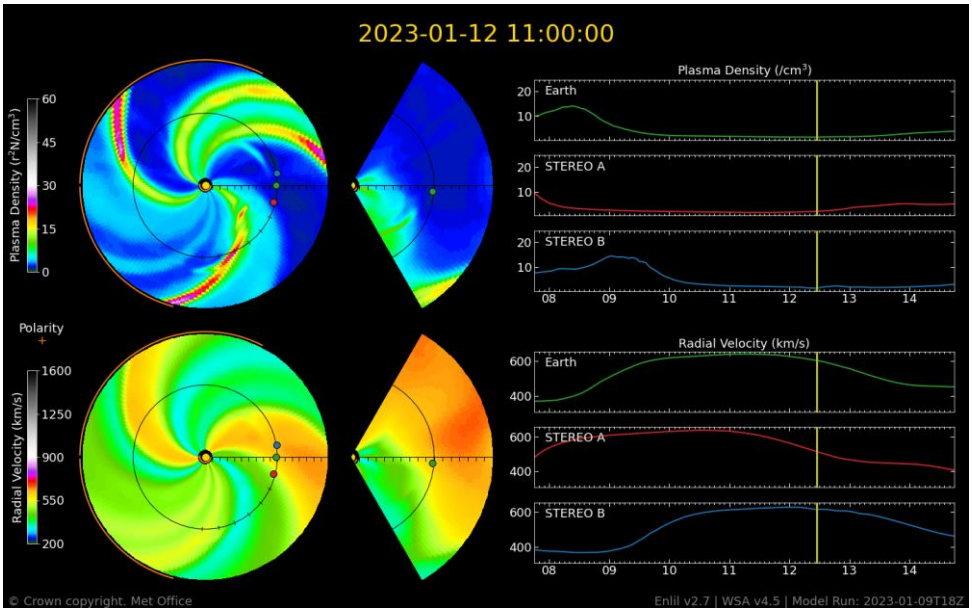
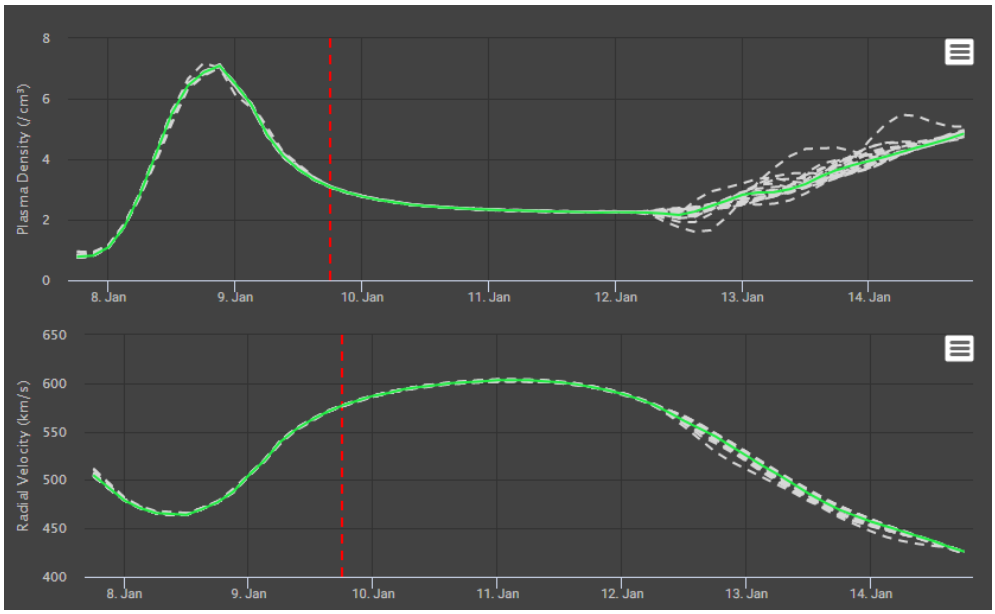
Figure 2: ENLIL and ENSEMBLE – shows a possible glancing blow from a CME on the 12th January – low confidence.





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Radio Blackouts - X-Ray Flares:
There are currently six sunspot regions on the visible. AR3182 and AR3181 (both Eki/Beta-Gamma-Delta) remain the two largest and most magnetically complex regions on the disc. Both are showing small and weak delta spots. However, AR3184 has been emerging over the southeast limb, which is now becoming more visible. This is now classified as a Dkc/Beta-Delta, with a delta spot seen in its trailing spots. A better analysis will be required once this regions comes fully into view on the disc. AR3185 in the north has emerged in the last 24 hours, but is currently small and simple. The remaining two regions, AR3180 (Hsx/Alpha) and AR3183 (Csi/Beta) are both currently simple and stable.

Solar activity has been High over the past 24 hours, with AR3184 producing an impulsive X1.9 flare, observed at 09/1850 UTC. This caused R2-R3 radio blackouts on the Sun facing side of Earth. However, this event did not produce a CME. Meanwhile, AR3181 produced an M2 flare, which did produce a CME. This has been analysed and may give a glancing blow at Earth on day 3 (12 Jan), although with confidence is low. Solar activity is likely to be mainly Low to Moderate with a chance of X-class flares. There is the potential for further regions to rotate around the east limb. Far side seismographs are indicating plenty of activity on the far side.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	70	70	70	70
Very Active	**R3 to R5 X Class**	Yes	25	25	25	25

Figure 3: GOES 16 X-Ray flares – shows the X1.9 flare originating from AR3184 and the M2 flare from AR3181 (which produced the CME).

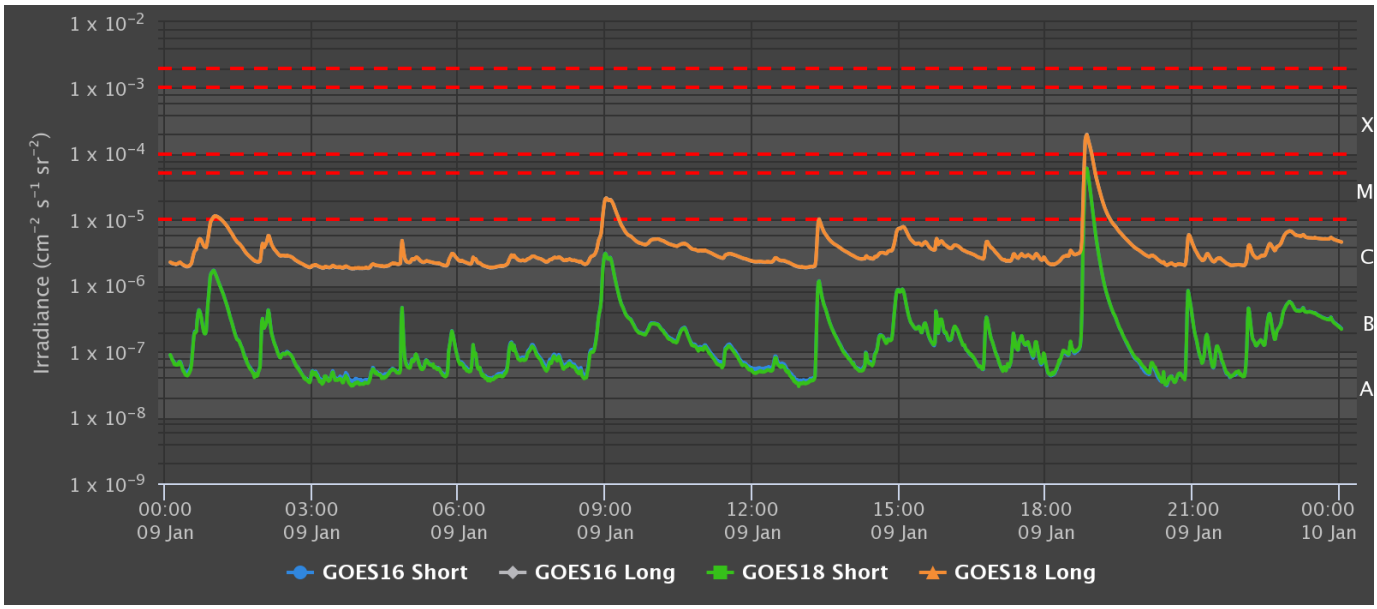

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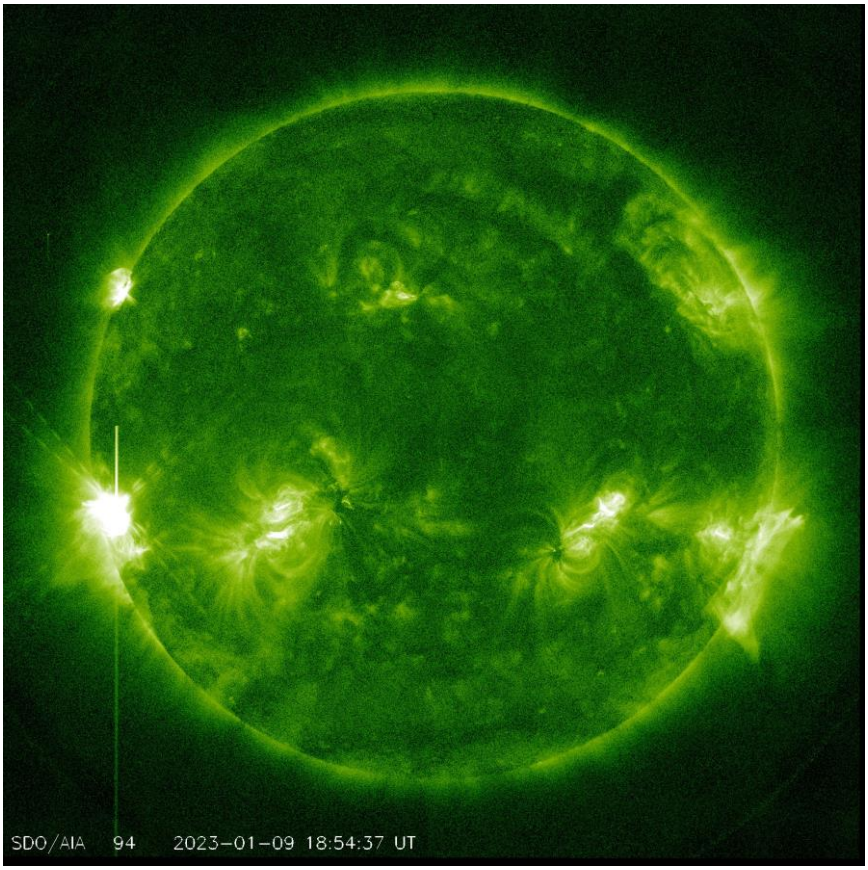
Figure 4: SDO/AIA 94 shows the X1.9 flare originating from AR3184 near the southeast limb.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is currently at background levels.

However, any significant flares will bring a risk of proton flux rising, with a slight chance of exceeding the S1/Minor Storm threshold. This is mainly due to the risk presented by both AR3182 and AR3181 as they are now rotating further westwards across the disc, towards a position where they are more likely to connect with Earth for proton storm events. AR3184 will also bear watching in the coming days, depending on how it appears as it rotates fully onto the disc.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	20	20	20	20
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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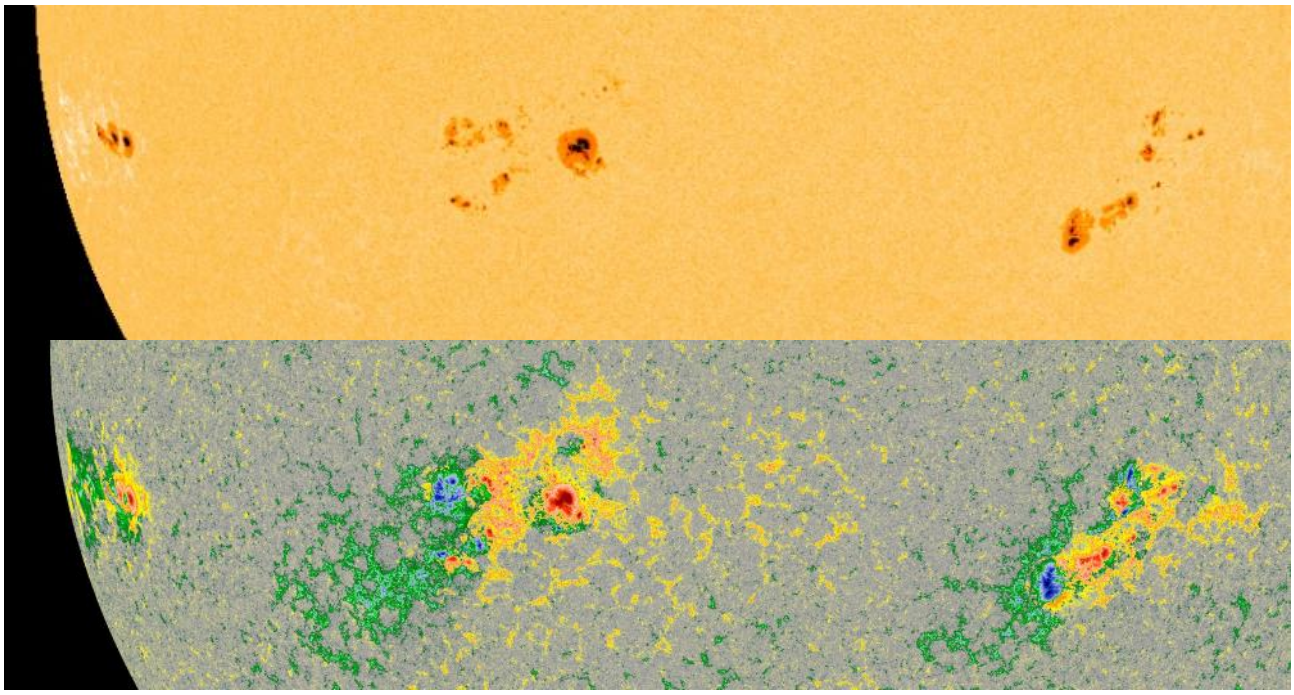
Figure 5: SDO intensitygram and magnetogram shows AR3181 (right), AR3182 (middle) and AR3184 (left). These are the largest and most complex magnetically and harbour 'delta' spots. These all present a significant flare risk, although proton risk is mainly from AR3181 and AR3182 due to their location.



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at largely background. Electron flux levels may rise a little in the next couple of days, but this is expected to be modest, perhaps reaching Moderate levels at the diurnal peaks. The onset of the next HSS from CH62 on Day 1 (10 Jan) is expected to cause a continued suppression of flux levels. This HSS is expected to be stronger than on previous rotation, with any electron response more likely to occur towards the end of this four day period - depending on any glancing blow from a CME on day 3 (12 Jan) which may keep electron flux levels suppressed.

Electron fluence is therefore expected to remain below the Active (1e8 integrated pfu) threshold for much of the period. Confidence in fluence remaining below Active through most of the period is reasonable, but lower for the likelihood and timing of any increase especially towards the end of the period, due to a possible glancing blow from a CME on the 12th Jan.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	10	20	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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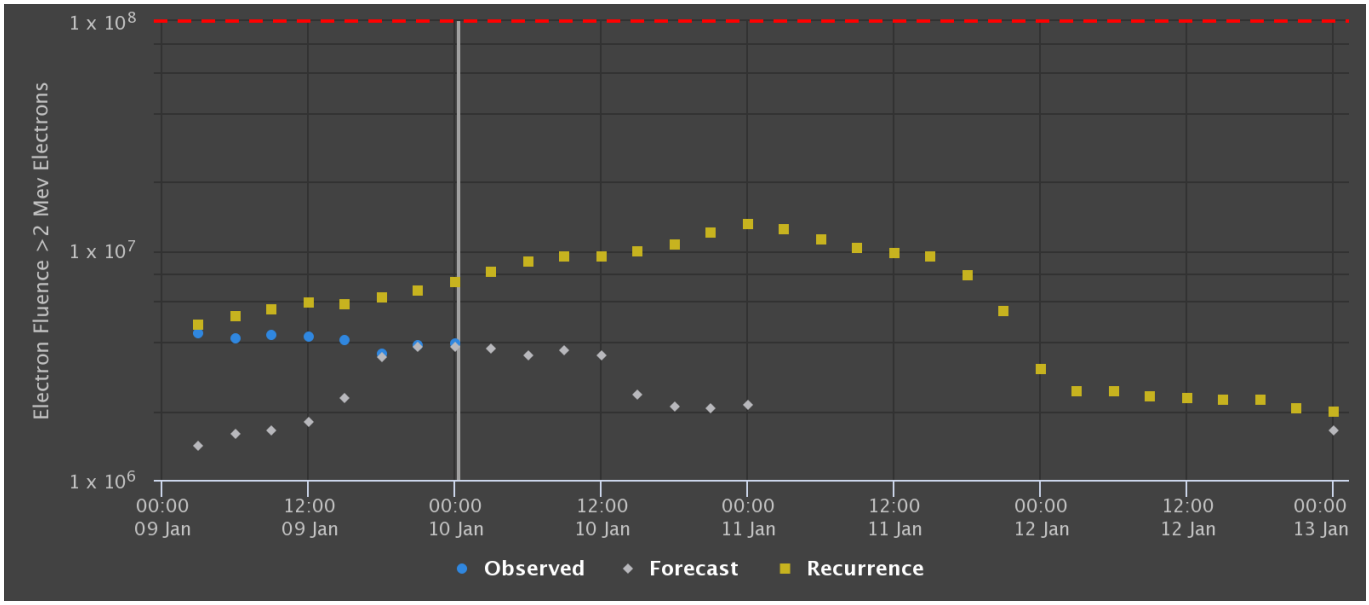
Figure 6: REFM fluence and observations



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